International Journal of Advances in Engineering and Management (IJAEM)
Volume 3, Issue 8 Aug 2021, pp: 500-511 www.ijaem.net ISSN: 2395-5252

"Investigational Evaluation on Utilization of Marble Waste Powder as Building Material by Partial Replacement in Cement Concrete"

Arun Kumar Thawait[1], Prof. L.P.Shrivastava[2]
[1]*Student, M.Tech (Structural Engineering), M.M.C.T, Raipur (C.G), India*
[2] *Assistant Professor, Dept.of Civil Engineering M.M.C.T, Raipur (C.G.) India*

Submitted: 01-08-2021 Revised: 08-08-2021 Accepted: 11-08-2021

ABSTRACT: Concrete is a basic construction material whose ingredients are cement, fine aggregates such as sand, coarse aggregate such as gravel, water and sometimes admixtures also. Cement is used as binding material, sand is used as filler material whereas gravel provides strength to the concrete. Cement as a ingredient in concrete is a costly material because the raw material use for the production of cement is nonrenewable as well as costlier. However if we get an alternatives options for cement by partially replacing it with waste material we can reduce the cost of construction. Among waste material marble waste is also one of them which are easily available. In the recent times requirement of high strength concrete has been increased in various construction such as in high rise building, post tensioning and in seismic prone area. In high strength concrete M35 is widely used, so in this work, M35 grade concrete is designed and partial replacement of cement is considered, the properties like workability and strength characteristics are investigated and compared with the conventional concrete.

KEYWORDS: MPC(Marble powder Concrete), NCA(Natural Coarse Aggregate), NFA(Natural Fine Aggregate), ASTM(American Society for Testing and Materials),

I. INTRODUCTION

Concrete is that the most generally used construction material within the world. It is formed by mixing cementing material, water and aggregates and sometime admixture in required proportion. The mixture which is formed by mixing is then placed in forms and allowed to cure, hardens to cure into rock like mass known as concrete. The strength, durability and other characteristics of concrete depend upon the ingredients, on the proportion of mix, the method of compaction and other controls during placing, compaction and curing. In limitless quantity of raw material are found which are used for making cement and aggregates are essential for the concrete. To overcome the above problem, studies have been initiated in the use of nonconventional materials for partial replacement of cement by fly ash in concrete, recycled and waste product such as quarry dust, marble dust and limestone dust in concrete. In recent years, the researchers and investigators has drawn serious attention a new concept generally termed as green concrete. Green concrete term means making a concrete environment friendly by using waste material fully or partially and reducing environmental problem and also giving attention toward to make concrete industry sustainable toward future generation. In the present study we use marble powder. Marble powder is used to partially replace with cement used inconcrete.

II. METHODOLOGY

This present chapter discusses the characteristics of the material and study with the help of experiment to evaluate the various properties of concrete containing marble dust. A standard mix design procedure was developed and various samples were tested. Concrete mix specimens containing marble powder in different proportions were prepared and tested for fresh and hardened concrete.

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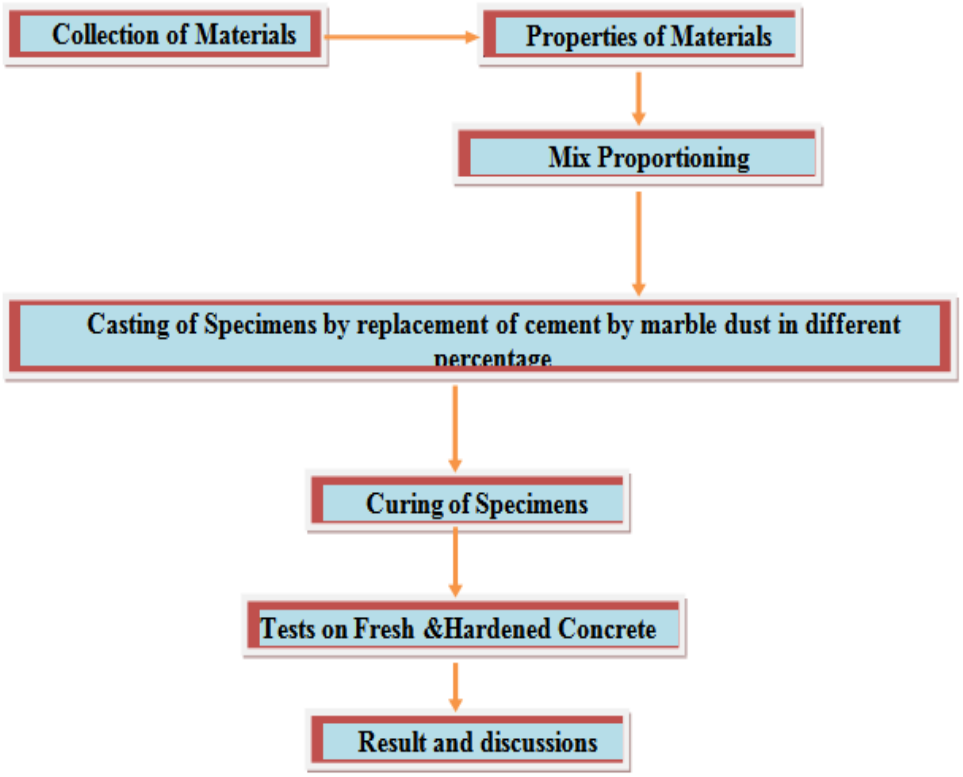

Fig 1 Methodology of the Study

Materials used in this investigation –
The aim of studying is to check the various properties of material with codal requirement and to design mix of particular strength. In the work various material which were used are describedbelow;

1. 43 grade OPCcement
2. Fine aggregate
3. Coarse aggregate
4. Marble dust
5. Water

Cement: In the course of investigation ordinary Portland cement (OPC) of 43 grades from a single lot was used. The various asper Indian standard IS: 8112:1989 are listed in are performed to determine the physical properties of cement table1.

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Sr .No	Characteristics	Values Obtained Experimentally	Required value Specified By IS 8112:1989
1.	Specific gravity	33.15	3.15
2.	Standard Consistency percent	227	24
3.	Initial Setting Time (minutes)	445	30 (minimum)
4.	Final Setting Time (minutes)	4420	600 (maximum)
5.	Compressive Strength 3Days 7Days 28Days	 24.5N/mm2 24.5N/mm2 44.6N/mm2	 23N/mm2(minimum) 33N/mm2(minimum) 43N/mm2(minimum)

Table 1 Physical properties of Cement

It can be observed from table that all the result satisfy the standard criteria.

Aggregate- The aggregate for concrete can be classified as coarse aggregate and fine aggregate. The coarse aggregate has larger size and in between 4.75mm to 63mm and fine aggregate are smaller size in between 150µm to 4.75mm.

coarse aggregate - In this experimental program, locally available coarse aggregate having the nominal size of 20mm was used in the project. The aggregate are tested as per IS: 383-1970. Various properties of coarse aggregate are found such as specific gravity, water absorption, etc

fine aggregate - In this experimental program, natural sand was locally procured and conformed to Indian standard IS: 383-1970. The natural sandwas sieved through 4.75 mm sieve to remove greater size particles and conforming to grading zone II. It was natural river sand light brown in colour.

Marble dust - Marble is a metamorphosed rock formed by the transformation of limestone which is a sedimentary rock by pressure and heat in the earth crust by geological process. Chemically it content calcite, dolomite or serpentine material which make marble as a crystalline rocks and other mineral differ from origin to origin.Marble dust is a waste produce amount of marble waste obtained during cutting process of marble.

Table 2 Physical Properties of Marble Dust

Property	Marble Dust
Specific gravity	2.58
Absorption (%)	2
Moisture content (%)	NIL
Sieve analysis	Zone-II

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Figure 2 **Marble powder**

The physical and chemical properties test are done is shown table 2 and table 3 respectively.
Concrete Mix Design

Constituents	Marble Dust (%)
SiO_2	15
Al_2O_3	3
Fe_2O_3	3
CaO	45
MgO	3
Na_2O	1
K_2O	0.75
Cl	0.1

Table 3 Chemical Properties of Marble Dust

The process of selecting suitable constituents of concrete and determining their relative quantity with the aim of producing a concrete of the required strength, durability, and workability as economically as possible, is known as the concrete mix design.

Table 4 Mix Proportion of M35 at Various Percentage of Marble Dust

Sample	Cement (kg/m^3)	MD (kg/m^3)	NCA (kg/m^3)	NFA (kg/m^3)	Water	WC	% Replaced
MPC0	426	0	1116	703	192	0.45	0
MPC1	404.7	21.3	1116	703	192	0.45	5
MPC2	383.4	42.6	1116	703	192	0.45	10
MPC3	362.1	63.9	1116	703	192	0.45	15
MPC4	340.8	85.2	1116	703	192	0.45	20
MPC5	319.5	106.5	1116	703	192	0.45	25
MPC6	298.2	127.8	1116	703	192	0.45	30

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Grade of concrete	Cement material per m3 of concrete (kg/m3)	NCA	NFA	Water	wc
M35	426	1116	703	192	0.45

Table 5 Initial data for mix design for M35 grade concrete

Mix proportions for normal concrete is 1:1.648:2.617

Preparing Mix and Casting

For casting all the moulds were cleaned and oiled properly. Cubes were fixed to right measurements before casting. Proper care was taken that there is no gaps left from where there is any chance of spilling out of slurry. Caution methodology was received in the complete process. Aggregates were measured first with an accuracy of 0.5 grams. Solid mix was prepared by hand blending. All the ingredients were mixed properly and completely. To this mix cement was added. These were mixed to get uniform colour. At that point water was added so no water was lost during the mixing process.

Cubes cleaned and oiled for every class were put on the vibrating table separately and filled in three layers with 25 blows of compaction in each layer. Vibration was stopped as soon as slurry showed up on the top surface of themould .The specimens were kept in the steel mould for 24 hours at suitable condition.

After that cubes were de-moulded with consideration so no edges were broken and were put in the curing tank at the suitable temperature for curing. The 27^0C was the room temperature while casting. After de-moulding the screws were loosed, cubes and cylinders were allowed to dry for one day before putting them in the temperature controlled curing tank for a time of 28 days.

Figure 3 Mixing of concrete

Figure 4 Concrete Cubes with Mould

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III. TESTS ON CONCRETE

- Slump test
- Compaction Factor
- Density
- Compressive Strength Test
- Tensile strength Test

Slumptest

Figure 5 Slump test

To measure the workability slump cone test was performed. The dimensions of cone are (i) top portion is a truncated cone having a size of 200 mm diameter at the bottom and 100 mm diameter at the top with a height of 300 mm. As soon as concrete is prepared, it is placed in the cone in three layers with 25 times of tamping each layer. The cone is then lifted up gradually and the fall in height of the concrete is measured, indicating the slump of the mix.

CompactionFactor

This test was performed to get the workability of concrete. Concrete sample was placed gently in the upper hopper to its brim using the hand scoop and levelled. Trapdoor was opened at the bottom of the upper hopper so that concrete falls into the lower hopper. Trapdoor of the lower hopper was opened and concrete was allowed to fall into the cylinder below.

Figure 6 Compaction Factor test

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Excess of concrete was cut from the top level of cylinder using trowels and leveled. Weight of the cylinder with concrete was taken to the nearest 10 g. This weight is known as the weight of partially compacted concrete(W1).
The cylinder was empted and then refilled with the same
concrete mix in layers. Weigh of the cylinder with fully compacted was taken. This weight is known as the weight of fully compacted concrete (W2).
Weight of empty cylinder was found (W). Compaction factor was found using the relation
(W1-W) / (W2-W)

Compressive Strength Test

The test specimens for compressive strength of cube are 150mmx 150mm x 150mm .The test specimens were cast in respective cast iron steel moulds. The mould specimens were applied with oil in all inner surfaces for easy removal of specimens during demoulding. Fresh concrete ismoulds. The mould specimens were applied with oil in all inner surfaces for easy removal of specimens during demoulding. Fresh concrete is filled in moulds in three equal layers. The mould is vibrated on a vibrating table to release the air trapped in the mix. The time of vibration was judged by the visual appearance of individual mixes to ensure full compaction. After casting, the specimens were demoulded after lapse of 24 hours and placed in the normal atmospheric condition.

Bulk Density Test

Bulk density of concrete is the mass of freshly mixed concrete required to fill the container of a unit volume. The Cylindrical measure jar was filled with freshly mixed concrete and compacted using tamping rod. The layers of 50 mm was placed and compacted with not less than 60 strokes.
After consolidation of the concrete, the top surface was struck-off and finished smoothly with a flat cover plate using great care.

All excess concrete was then cleaned from the exterior and filled measure jar was weighed (W). Density of Concrete (W1) was calculated by dividing the weight of fully compacted concrete in the cylindrical measure by the capacity of measure in kg/m3. Length of mould is 29cm and diameter is 16cm hence volume was calculated to be 0.006m3

Figure 7 Bulk Density Apparatus

TensileTest

Splitting tensile strength is the measure of tensile strength of the concrete which is determined by splitting the cylinder across its diameter. This is an indirect test method to determine the tensile strength of concrete of test specimen of cylinders.

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The load was applied using compression testing machine. Testing was carried out for tensile test on cylinder. Split tensile strength is determined on 7th day and 28th day.

Figure 8 compressive strength test

Figure 9.prepared cylinder

Figure10 split tensile test

IV. RESULT AND DISCUSSION

SlumpTest

Workability of concrete was checked by Slump cone test which was conducted for each mix design. Table 6 shows the result of slump test of M35 at various percentage of Marble Dust replaced with cement

Sample	Slump Value(mm)
MPC0	75
MPC1	73
MPC2	70
MPC3	65
MPC4	59
MPC5	51
MPC6	47

Table 6 Slump values

Compaction FactorTest

This test was performed to get the workability of concrete. Table 7 show CF of various mixes and comparison of it.

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Sample	Partially Compacted Concrete (W1).Kg	Compacted Concrete (W2)Kg	Empty Cylinder (W) Kg	Compaction Factor (W1-W) / (W2-W)
MPC0	5.85	7.1	.6	.9
MPC1	5.6	6.9	.6	.89
MPC2	5.36	6.32	.6	.88
MPC3	4.7	6.35	.6	.87
MPC4	4.4	6.12	.6	.85
MPC5	3.9	5.15	.6	.79
MPC6	2.5	5.13	.6	.75

Table 7 Compaction factor values

Bulk Density Test

Bulk density of concrete is the mass of freshly mixed concrete required to fill the container of a unit volume .Density of concrete is a measure of its unit 0weight. In this work, the density of the normal concrete is found to be 2344.11 kg/m^3 and the density of the marble dust concrete decreases gradually which may be due to the slightly lower specific gravity of the marble dust than cement.

Sample	Density (kg/m^3)
MPC0	2344.11
MPC1	2323.16
MPC2	2302.54
MPC3	2287.24
MPC4	2271.36
MPC5	2263.46
MPC6	2251.19

Table 8. Bulk density value

Compressive StrengthTest

The results of compressive strength of concrete with marble dust with different addition percentage are given in Table 9 below shows the compressive strength and percentage increase and decrease at 28 days.

Sample	Compressive strength	Average compressive strength	% Increase or Decrease to Control
MPC0	44.3	44.2	0
	44.4		
	43.9		
MPC1	45.9	45.8	3.61
	45.7		
	45.8		

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MPC2	46.7 47.1 46.9	46.9	6.1
MPC3	45.1 45.4 45.1	45.2	2.26
MPC4	42 41.5 41.3	41.6	-5.88
MPC5	38.1 38.4 38.7	38.4	-13.11
MPC6	34.2 33.8 34.3	34.1	-22.35

Table 9 Compressive Test Result at 28th days

Split TensileTest

Tensile strength is an important property of concrete because concrete structures are very much vulnerable to tensile cracking and various kinds of loading. Tensile strength is very less as compared to compressive strength test of concrete. Table below shows split tensile test results and percentage increase and decrease after 28 days.

Sample	**Tensile strength 28 days N/mm^2**	**% Increase or Decrease to Control Concrete**
MPC0	5.19	0
MPC1	5.21	0.38
MPC2	5.41	4.23
MPC3	5.31	2.3
MPC4	5.02	-3.2
MPC5	4.96	-4.4
MPC6	4.83	-6.9

Table 10 Tensile Test Result at287th day

V. CONCLUSION

This work evaluated the possibility of replacing cement in concrete with marble waste dust at different levels (0%, 5%, 10%, 15%, 20%, 25% and 30%) produced in local industries of, Chhattisgarh, Concrete mix design of 35MPa and water cement ratio of 0.45 was used. Based on the results from this study, the following general conclusions could be made:

Slump test - With increasing the percentage of marble dust addition in the concrete the workability of concrete decreases, indicated by decrease in slump. This can be mainly attributed to higher water demand of marble dust. However at 10% &15% addition the slump value is 70 & 65 mm hence the mix is reasonably cohesive andworkable.

Compaction Factor - Degree of workability is low to medium (0.75-0.90) hence concrete can be used in foundation work and simple reinforced section withvibrations.

Bulk density - The density of the normal concrete is found to be 2344.11 kg/m3 and the density of the marble waste dust concrete is 2323.16 kg/m3 at 5% replacement. The difference is due to the slightly lower specific gravity of the

marble dust thancement.

Compressive strength - Compressive strength of all grades of concrete change when completely different proportion of cement is replaced by a varied proportion of marble dust as compared with referral concrete. However in some proportion there's increase in strength that is nearer to the strength of referralconcrete.

We can replace 10 to 15 percent of cement by marble dust as it gives high strength as well as nearer strength to referralconcrete.

Test was also carried out to replace 25 to 30 percent of cement by marble but its strength was very lower than referral concrete so it is of nouse.

There is a trend of increase in later age strength in all of the concretemixes.

Split Tensile Strength - Tensile strength of all concrete mixes changes when different proportion of marble dust is replaced withcement.

When we replaced 10% of marble dust in concrete then tensile strength obtained is maximum i.e. 5.41 N/mm2 also the strength in 5% and 15% replacement strength is greater/nearer to referral concrete hence we can use 05-15 % marble dust in place of cement inconcrete

Hence from the above study it is concluded that 5% to 15% of marble dust can be used in place of cement as it gives results which are higher or similar to that of referral concrete in consultation with experts.

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